THE NEW ATLAS OF VARIABLE STARS.*

By the Rev. Father J. G. Hagen, S. J.

Dear Sir:—In compliance with your kind invitation to send to you a description of the forthcoming Atlas of Variable Stars, I offer the following remarks on the plan of the work, on the observations, and on the construction of the charts:—

I. The Atlas is *planned* to contain all variable stars from the north pole to $-25°$ Declination. For the present are excluded the the new stars, called *Novæ*, and the recently discovered stars, whose variability and character are not yet sufficiently established.

The Atlas is divided into five *Series*, the first three of which comprise those Variables that fall below the 10th magnitude at their minimum phase, while the fourth series contains those that can be followed with a three-inch telescope throughout their entire variation, and the fifth gives all the naked-eye Variables. The first three Series cover respectively the zones from $-25°$ to the equator, from the equator to $+25°$ and from $+25°$ to the pole. Arrangements have been made with the publisher by which each of the five series can be procured separately, so that observers will be enabled to select for themselves that Series which best suits their equipment and their location with regard to the equator. Beginners especially will find this division of the whole Atlas advantageous, as they will have the whole program of their work marked out, without the danger of omitting interesting variables or of wasting time upon unsuitable objects.

The following description is confined to the first three Series, as the fourth and fifth will require special explanations.

II. The *observations* for the first three Series were the most laborious, and differ in many respects from those required for the fourth and fifth Series, on account of the many faint stars that had to be determined with regard to position and magnitude.

The field chosen for these three Series is one degree square, in whose center is the variable. In this square all the BD stars

* This letter by Father Hagen is in answer to one sent to him requesting information concerning his new Atlas of Variable Stars. The value of the work is evident, and its appearance should give new impetus to the study of variables. It is perhaps not out of place to add that the systematic observation of variable stars is one of the most profitable lines of work into which the amateur can enter. It is a field in which any member of the Astronomical Society of the Pacific can do work, the results of which will be of real benefit to the Science of Astronomy. Editor.

were plotted, and then identified in the sky by means of a five-inch equatorial. Not only were the errors noted, but all the stars of a chart were connected with each other by sequences of brightness, according to ARGELANDER'S method, beginning with the brightest star. This operation was repeated after an interval of many months, generally a year.

After the first three Series were finished in this way, the charts were taken to the 12-inch equatorial for the insertion of the fainter stars. For these fainter stars a smaller square was marked around the variable, viz. half a degree square, covering only one-fourth of the area of the whole chart. The positions of all the stars within this smaller square, visible in our 12-inch refractor, and of all the BD stars of the whole chart, were then determined by means of a semi-circular glass scale, measuring 30′, and divided into ten parts. Thus 3′ could be read directly, and 0′.3 by estimation. The lines were cut in the glass by means of a dividing engine and then painted black by hand rather coarsely, to make them visible in the light of the stars without field illumination. Hence the glass scale was similar to the one used for the BD, but the method of observation was different. The declinations were determined separately from the Right Ascensions while the telescope was following the stars by means of the driving clock. For the R. A. the telescope remained clamped, but the clock was stopped, and the approach of the stars to the vertical diameter of the glass scale was recorded on the chronograph. This record was made three times, not so much to reach greater accuracy as to make sure that the combinations of the Decl. and R. A. were placed beyond doubt. Since the glass scale covers only one-half of a chart, the northern and southern parts of the charts had to be observed separately. In the catalogue the Decl. and R. A. are given differentially from the Variable as zero point. The inclination of the glass reticle to the hour circle was determined from several stars whose position was known either from catalogues or from kind communications of astronomers now engaged in making the southern zones of the A. G., or finally from observations with our own ERTEL transit instrument. All these observations and computations for correcting the inclination of the reticle were carried out by Rev. Father J. T. HEDRICK, S. J.

The chronograph sheet was read off and the new stars plotted on the chart, in different ink, on the morning after the observa-

tion, in order to compare the chart with the sky, and to estimate the brightness of the stars on the first succeeding clear night. All the stars, including the BD stars, were then connected by sequences of brightness, from the brightest to the faintest, and these estimates were repeated about a month later. Hence, all the fainter stars were estimated in brightness twice, besides occasional revisions, and the BD stars four times. Each chart was therefore compared with the sky at least five times.

For the construction of charts it was necessary to transform the sequences of steps into a series of magnitude. For this purpose the steps observed in the 5-inch telescope had to be reduced to those observed in the 12-inch refractor, by a multiplying factor, which changed from one chart to another, and then they were combined into a mean value. The value of one step, expressed in magnitude, had to be found so as to make the computed magnitudes agree as nearly as possible with any of the adopted scales (in this case the BD), at least between the limits 7^m and 10^m. How the step value was computed, and from what starting point it was applied, is of little importance. The test of the method will be the agreement between the two series of magnitudes. This same step value was then applied to the sequences of the fainter stars, without regard to the different limits of magnitude which would thus be reached on different charts. The lowest limit is about $13^m.5$, which is in good accord with the limit expected from a comparison of our charts with those of CHARCORNAC, PETERS, and PALISA. That this lowest limit was not reached on all charts is partly owing to the well-known fact that estimates of steps do not run uniformly from the brighter to the fainter stars, and hence require a variable step value for their reduction to a uniform photometric scale, and partly also owing to the fact that telescopes have no fixed limit of visibility for all parts of the sky and all times of the year. Hence, the magnitudes assigned to the fainter stars of our charts are not to be considered as an extension of the BD scale below the 10th magnitude, but only as serving the immediate purpose of engraving the charts. New magnitudes can be deduced from the steps as soon as a photometric scale is established for stars below the 10th magnitude. All the computations of the magnitudes were made by Mr. M. ESCH, S. J., assistant of this observatory. It may be well to state that the observations at the telescope of positions and brightness were all made by myself.

III. The *charts* of the first three Series measure, as has been said before, one degree in each direction, but the field that contains the faint stars below the 10th magnitude measures only one-half degree in each co-ordinate. The variable star is placed in the middle of the chart, and designated by a circle and a dot in the center, which correspond respectively to its maximum and minimum brightness. The identification of the variable was considered the most important point of the Atlas, and no chart is sent to the engraver before the variation of the star in the center has been established by actual observations. There is good ground for the hope that all errors of this kind have been avoided. The projection of the net is not optical, but artificial, the meridian lines being all parallel and the horizontal lines at equal distances from each other. The color of the net is red, and no letters are printed on the charts. Thus, in red light, which is found very agreeable to the eye when frequent changes from light to darkness are to be made, nothing appears on the chart except the black disks of the stars. This gives them the nearest resemblance to the sky, and facilitates recognizing the configuration.

The inscription of each chart is supposed to furnish everything necessary for the night work, while the catalogue gives other data useful for the computations.

The *Atlas* is published in Berlin, by Mr. FELIX L. DAMES (Voss Strasse, 32). It will be agreeable to your readers to learn that Miss CATHERINE WOLFE BRUCE, so well known for her many contributions to astronomical science, has placed in the hands of Professor EDWARD C. PICKERING a security of nearly two thousand dollars, which, while not covering the expense of engraving and printing of the whole Atlas, has encouraged the publisher to run the risk of this publication.

J. G. HAGEN, S. J.

GEORGETOWN COLLEGE OBSERVATORY, March 19, 1898.

OBSERVATIONS OF o *Ceti* (*Mira*). 1897–98.

BY ROSE O'HALLORAN.

The variable star o *Ceti* attained a greater magnitude last November than during any of the recent years since the maxima commenced to occur in months when the constellation was not obscured by sunlight. Observations were taken of its rela-